

从 ShardingSphere 性能提升 场景探析 Java 性能工具及实践

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- 在与 openGauss 社区合作的 16 节点达成 TPC-C 1000 万 tpmC 的性能目标中，参与 ShardingSphere 性能优化
- 目前专注于 ShardingSphere-Proxy 研发



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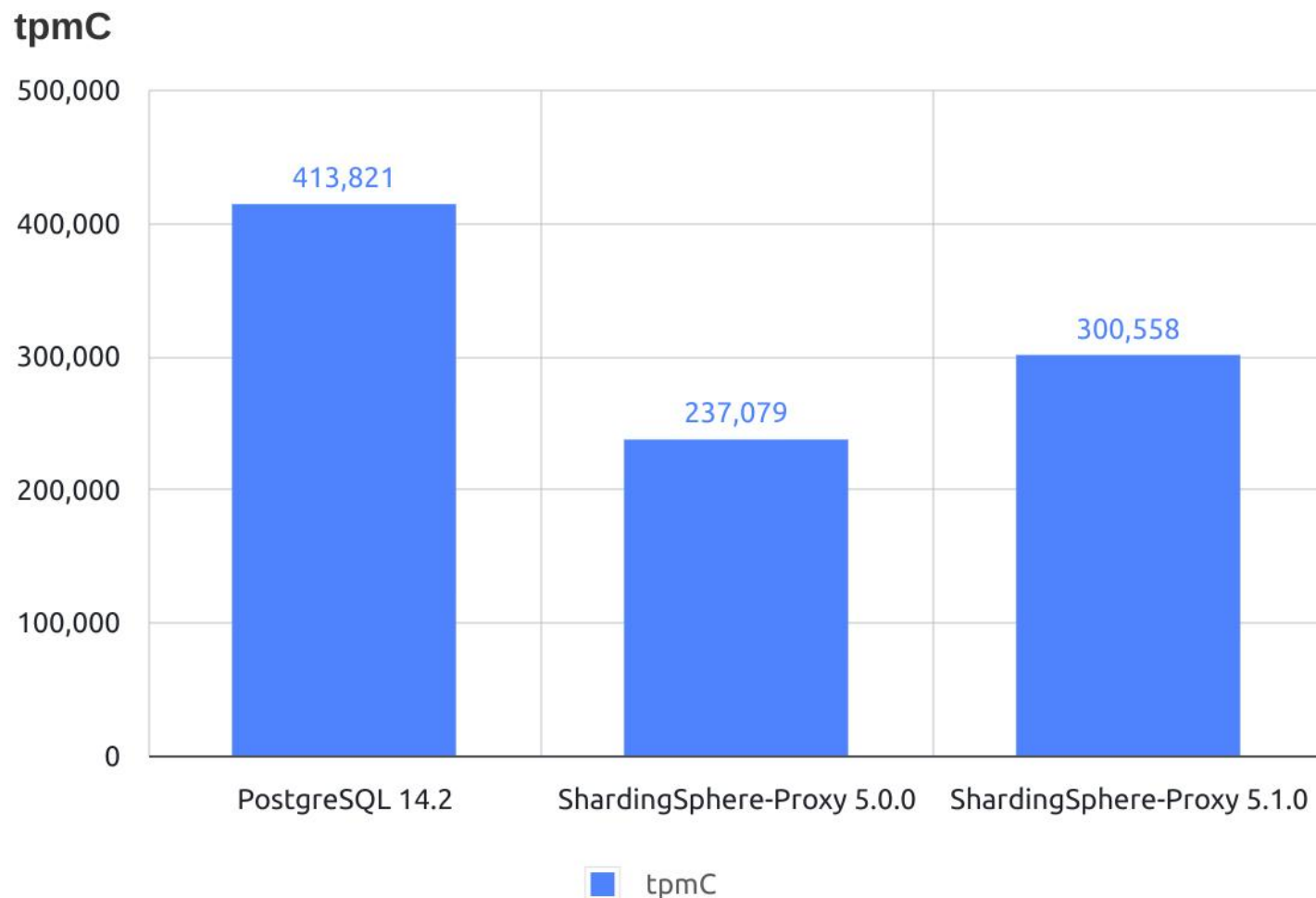
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借助 JMH 更准确地测量代码性能

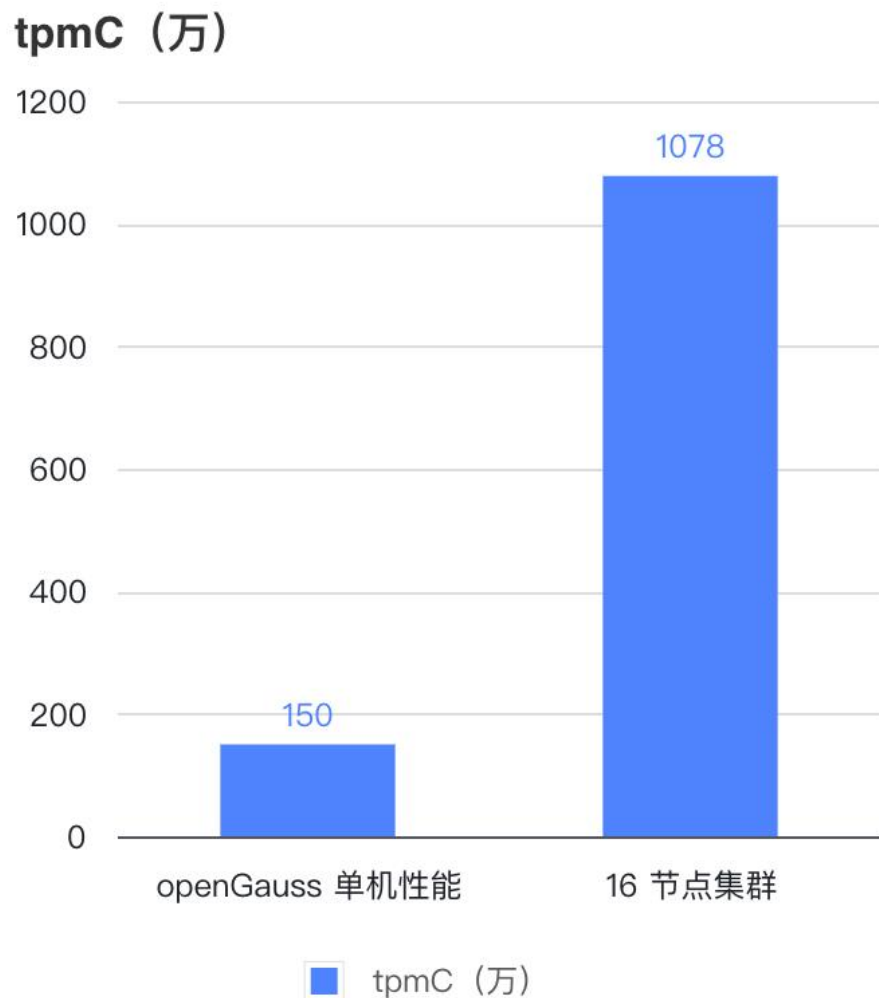


场景 1: ShardingSphere-Proxy 透传对比直连 PostgreSQL



	ShardingSphere-Proxy	PostgreSQL	BenchmarkSQL
CPU	2 * Intel(R) Xeon(R) CPU E5-2650 v4 @ 2.20GHz	2 * Intel(R) Xeon(R) Gold 6146 CPU @ 3.20GHz	2 * Intel(R) Xeon(R) CPU E5-2650 v4 @ 2.20GHz
RAM	96 GB 2400MHz	512 GB 2666MHz	96 GB 2400MHz
硬盘	/	AVAGO SCSI 240GB	/
网卡	10 Gb	10 Gb	10 Gb
操作系统	CentOS 7.9	CentOS 7.9	CentOS 7.9
软件环境	Java 17.0.1 ShardingSphere-Proxy 5.0.0 / 5.1.0	PostgreSQL 14.2	BenchmarkSQL 5.0
其他配置	网卡队列绑核 0-1,24-25 ShardingSphere-Proxy 绑核 2-23,26-47	fsync=off full_page_writes=off shared_buffers=128 GB	

场景 2: 共 16 节点 ShardingSphere-JDBC 5.1.1 + openGauss 数据分片



配置	8 x openGauss	7 x ShardingSphere-JDBC	1 x ShardingSphere-Proxy
CPU	128 核 2 路鲲鹏 920	128 核 2 路鲲鹏 920	128 核 2 路鲲鹏 920
内存	768GB	768GB	768GB
系统盘	1TB	1TB	1TB
数据盘	3 x 4TB NVMe SSD	无	无



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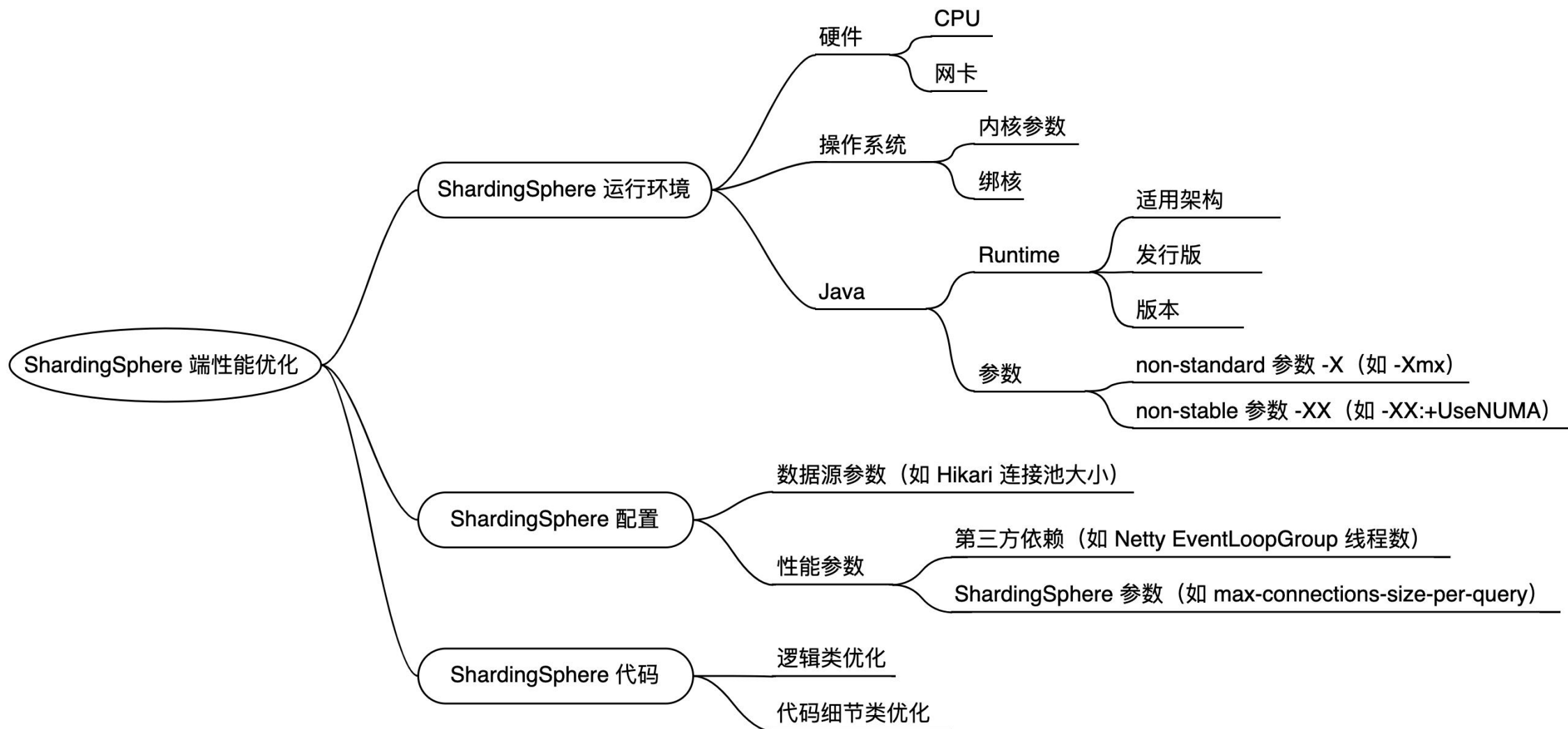
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ShardingSphere 性能优化思路



案例：云服务器单队列网卡软中断性能瓶颈

```
top - 14:40:59 up 246 days, 3:31, 4 users, load average: 12.09, 16.67, 29.95
Tasks: 409 total, 1 running, 408 sleeping, 0 stopped, 0 zombie
%Cpu(s): 17.4 us, 5.7 sy, 0.0 ni, 75.2 id, 0.0 wa, 0.0 hi, 1.7 si, 0.0 st
GiB Mem : 94.1 total, 17.4 free, 31.3 used, 45.5 buff/cache
GiB Swap: 0.0 total, 0.0 free, 0.0 used. 45.0 avail Mem
```

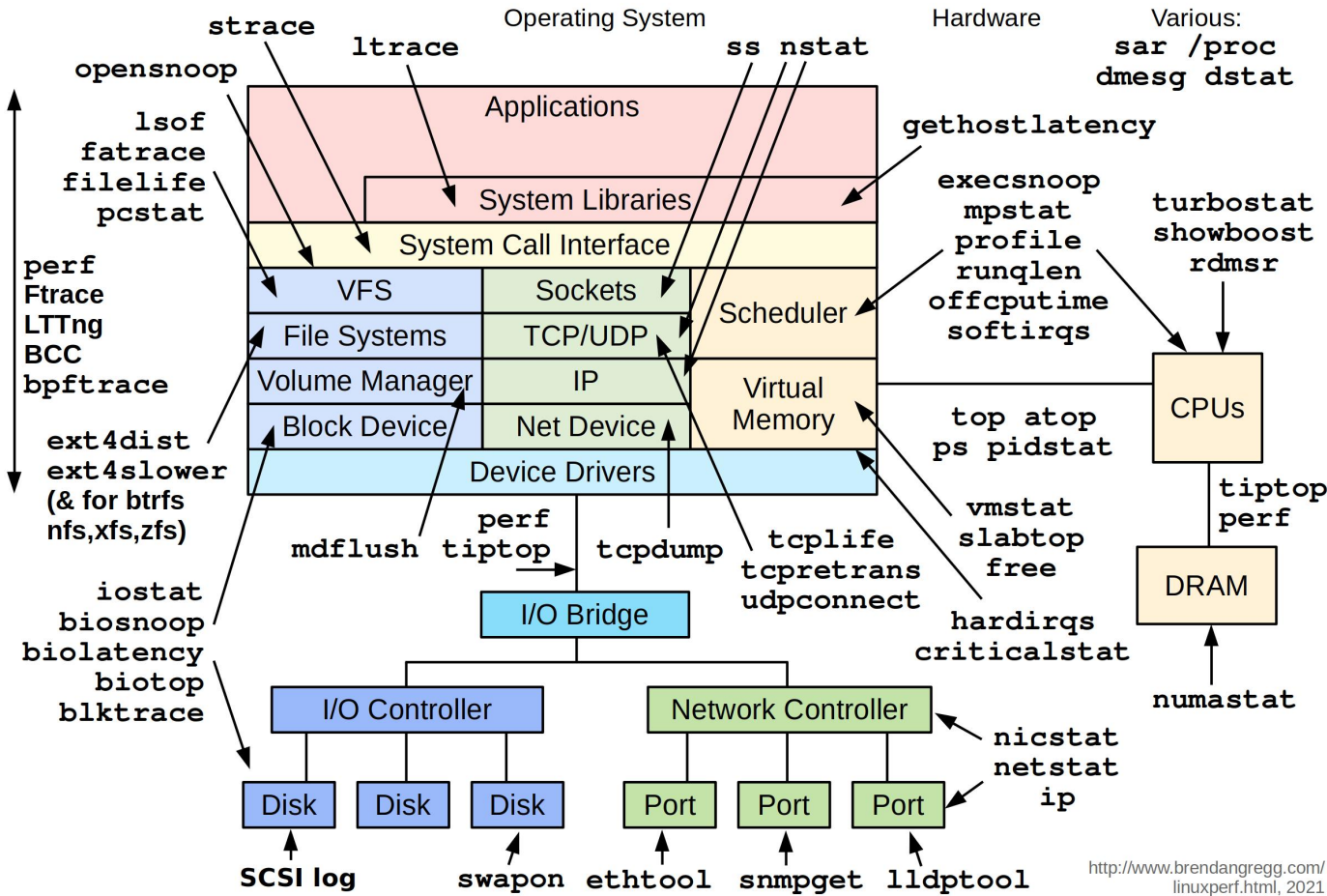
PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
47695		20	0	35.8g	16.9g	23168	S	1139	18.0	39:31.25	java -Xmx16g -Xmn16g

```
top - 14:39:34 up 246 days, 3:30, 4 users, load average: 15.60, 18.27, 31.68
Tasks: 410 total, 2 running, 408 sleeping, 0 stopped, 0 zombie
%Cpu0 : 0.7 us, 0.0 sy, 0.0 ni, 0.3 id, 0.0 wa, 0.0 hi, 99.0 si, 0.0 st
%Cpu1 : 48.5 us, 15.4 sy, 0.0 ni, 36.1 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu2 : 46.6 us, 15.5 sy, 0.0 ni, 37.8 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu3 : 46.4 us, 15.6 sy, 0.0 ni, 38.1 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu4 : 46.5 us, 14.4 sy, 0.0 ni, 39.1 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu5 : 45.5 us, 15.2 sy, 0.0 ni, 39.4 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu6 : 44.7 us, 16.0 sy, 0.0 ni, 39.3 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu7 : 44.9 us, 15.2 sy, 0.0 ni, 39.9 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu8 : 45.2 us, 14.4 sy, 0.0 ni, 40.5 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu9 : 44.7 us, 14.6 sy, 0.0 ni, 40.7 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu10 : 44.7 us, 15.3 sy, 0.0 ni, 40.0 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu11 : 46.2 us, 14.0 sy, 0.0 ni, 39.9 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu12 : 21.1 us, 7.7 sy, 0.0 ni, 71.1 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu13 : 20.6 us, 7.3 sy, 0.0 ni, 72.1 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu14 : 19.8 us, 7.0 sy, 0.0 ni, 73.2 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
%Cpu15 : 20.5 us, 7.0 sy, 0.0 ni, 72.5 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
```

解决思路：

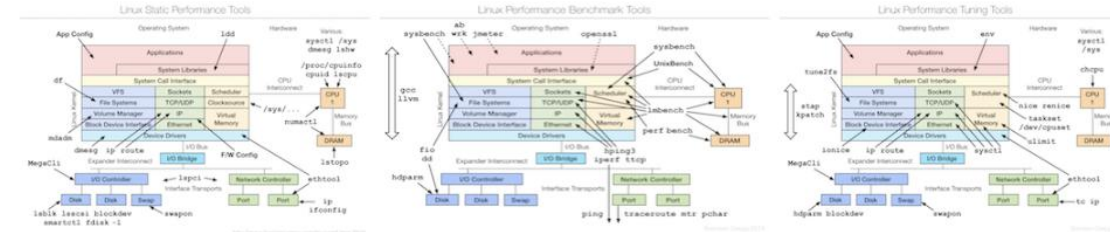
- （硬件支持）网卡多队列绑核
- irqbalance

Linux Performance Observability Tools

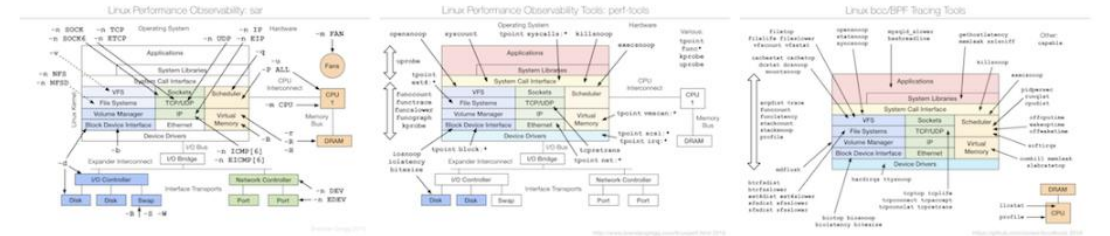


<http://www.brendangregg.com/linuxperf.html>, 2021

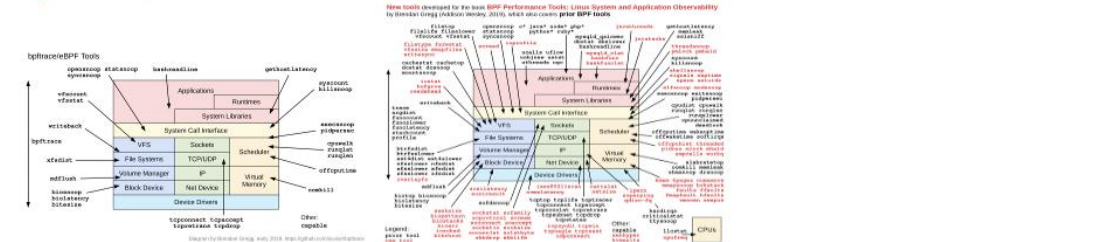
static, benchmarking, tuning:



sar, [perf-tools](#), [bcc/BPF](#):



[bpftrace](#), [BPF book](#):



Images license: creative commons [Attribution-ShareAlike 4.0](#).

JVM 升级与参数调优带给 ShardingSphere 的性能收益

```
44 VERSION_OPTS=""
45 if [ $int_version = '8' ] ; then
46     VERSION_OPTS="-XX:+UseConcMarkSweepGC -XX:+UseCMSInitiatingOccupancyOnly -XX:CMSInitiatingOccupancyFraction=70"   Java 8 参数
47 elif [ $int_version = '11' ] ; then
48     VERSION_OPTS="-XX:+SegmentedCodeCache -XX:+AggressiveHeap"   Java 11 参数
49     if $is_openjdk; then
50         VERSION_OPTS="$VERSION_OPTS -XX:+UnlockExperimentalVMOptions -XX:+UseJVMCICompiler"   Java 11 OpenJDK 追加参数
51     fi
52 elif [ $int_version = '17' ] ; then
53     VERSION_OPTS="-XX:+SegmentedCodeCache -XX:+AggressiveHeap"   Java 17 参数
54 else
55     echo "unadapted java version, please notice..."
56 fi
57
58 JAVA_OPTS=" -Djava.awt.headless=true "
59                                     公共参数
60 JAVA_MEM_OPTS=" -server -Xmx2g -Xms2g -Xmn1g -Xss1m -XX:AutoBoxCacheMax=4096 -XX:+UseNUMA -XX:+DisableExplicitGC -XX:LargePageSizeInBytes=128m ${VERSION_OPTS}"
```

* 在 128 核鲲鹏 920 环境运行 ShardingSphere, 使用 Java 17 相比 Java 8 性能提升 5% ~ 10%

VM Options Explorer -- chriswhocodes.com

VM Options Explorer - Op x +
 chriswhocodes.com/hotspot_options_openjdk17.html

I make tools for understanding the Java Virtual Machine. Please support my work by [sponsoring me on GitHub](#). Thank you!

- FullJEP
- JEPMap
- JEPSearch
- hsdis
- JITWatch
- JaCoLine
- VM Options Explorer
- VM Intrinsic Explorer
- GC Explorer
- Optimizing Java

VM Options Explorer - OpenJDK17 HotSpot 收录了主流 JDK 发行版的参数集合

OpenJDK HotSpot Options added/removed OpenJDK options also hosted on foojay.io												Alibaba Dragonwell 8 Dragonwell 11 Dragonwell 17			Amazon Corretto 8 Corretto 11 Corretto 17									
JDK6	JDK7	JDK8	JDK9	JDK10	JDK11	JDK12	JDK13	JDK14	JDK15	JDK16	JDK17	JDK18	JDK19	JDK20										
Azul Systems				BellSoft				Eclipse				GraalVM 22.0.0.2		GraalVM native-image 22.0.0.2										
Zing		Zulu										JDK11		JDK17		JDK11		JDK17						
JDK8	JDK11	JDK8	JDK11	JDK13	JDK15	JDK16	JDK17	JDK18	Liberica 8	Liberica 11	Liberica 17	Liberica 18	Temurin 8	Temurin 11	Temurin 17	Temurin 18	CE	EE	CE	EE	CE	EE	CE	EE
																	EE-only	EE-only			EE-only		EE-only	EE-only
Microsoft Microsoft 11 Microsoft 16 Microsoft 17			OpenJ9 OpenJ9		Oracle										SAP SapMachine									
JDK6	JDK7	JDK8	JDK9	JDK10	JDK11	JDK12	JDK13	JDK14	JDK15	JDK16	JDK17	JDK18												

主要关注：
 define_pg_global
 product
 product_pd

Search OpenJDK17 HotSpot Options: 搜索框, 搜索范围涵盖所有字段

Name	Since	Deprecated	Type	OS	CPU	Component	Default	Availability	Description	Defined in
-XX: 参数名	引入版本	Deprecated	Show All	Show All	Show All	Show All	Show All	Show All	参数描述	定义文件
AggressiveHeap	OpenJDK10		bool	操作系统	CPU 架构	gc	false	product	Optimize heap options for long-running memory intensive apps	share/gc/share
AggressiveUnboxing	OpenJDK8		bool			c2	true	product	Control optimizations for aggressive boxing elimination	share/opto/c2_
EnableVectorAggressiveReboxing	OpenJDK16		bool			c2	false	product	Enables aggressive reboxing of vectors	share/opto/c2_127.0.0.1



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借助 async-profiler 发现 ShardingSphere 代码优化点

async-profiler 是针对 JVM 的采样分析工具。

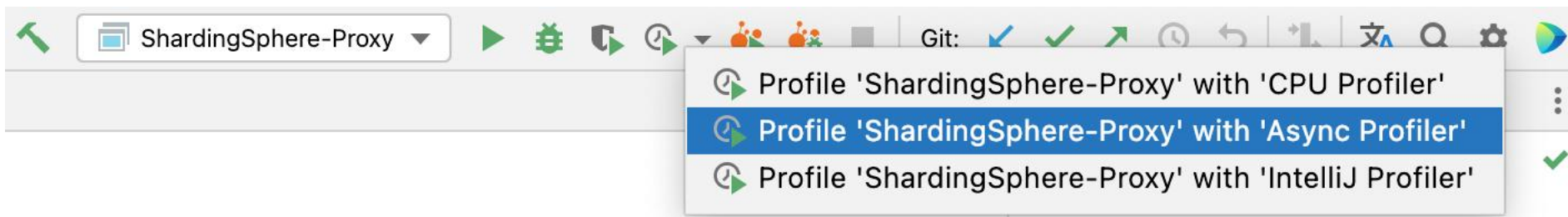
特点:

- ✓ 不受 Safepoint Bias 影响
- ✓ 性能开销低 (采样频率可调整), 生产可用
- ✓ 使用方便, 可基于 Java Agent 启动, 或指定 PID 连接已有 JVM
- ✓ 支持多种输出格式 (HTML、SVG、JFR 等) 及格式转换

支持事件:

- ✓ CPU 周期
- ✓ 硬件和软件性能指标, 如缓存未命中、分支未命中、缺页、上下文切换等
- ✓ Java 堆中的分配
- ✓ 锁, 包括 Java 对象监视器和 ReentrantLock
- ✓

```
$ profiler list 163601
Basic events:
  cpu
  alloc
  lock
  wall
  itimer
Java method calls:
  ClassName.methodName
Perf events:
  page-faults
  context-switches
  cycles
  instructions
  cache-references
  cache-misses
  branch-instructions
  branch-misses
  bus-cycles
  L1-dcache-load-misses
  LLC-load-misses
  dTLB-load-misses
  rNNN
  pmu/event-descriptor/
  mem:breakpoint
  trace:tracepoint
  kprobe:func
  uprobe:path
```



JFR vs perf vs async-profiler

	JFR	perf	async-profiler
Java stack	Yes	No interpreted	Yes
Native stack	No	Yes	Yes
Kernel stack	No	Yes	Yes
JDK support	11+, 8u262+	8u60+	6+
OS support	All	Linux only	Linux, macOS*
Permanent overhead	0	1-5%	0
System-wide profiling	No	Possible	No

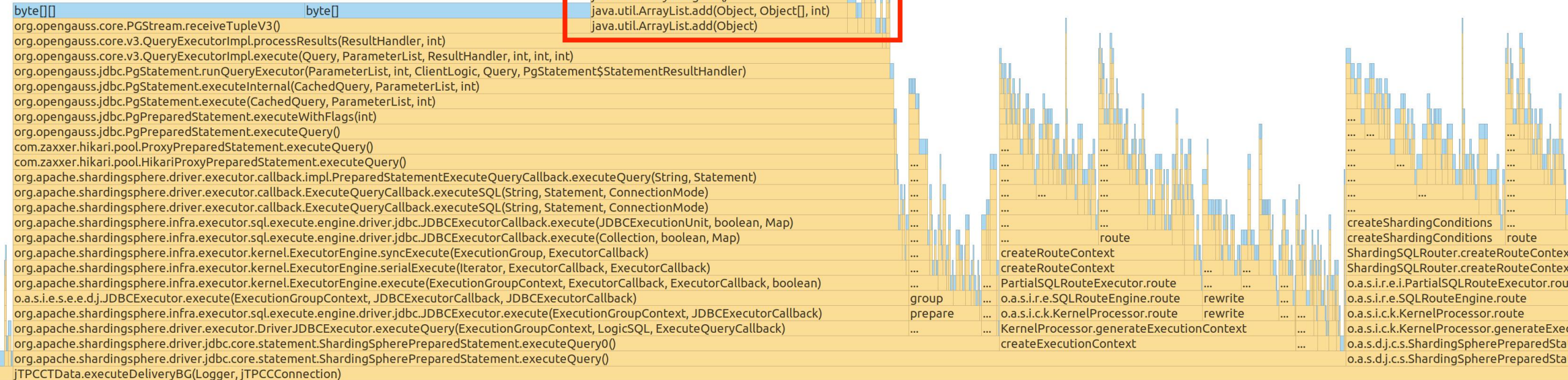
来源: <https://github.com/apangin/java-profiling-presentation/blob/master/presentation/java-profiling.pdf>

async-profiler 采集内存分配火焰图

ArrayList 扩容开销

java.lang.Object[]
61,931,235,672 bytes, 100% of parent, 2.14% of all

java.lang.Object[]
java.util.Arrays.copyOf(Object[], int)
java.util.ArrayList.grow(int)
java.util.ArrayList.grow()
java.util.ArrayList.add(Object, Object[], int)
java.util.ArrayList.add(Object)



async-profiler 采集其他事件

Flame Graph	Call Tree	Method List	Timeline	Events			
				Start Time			
				JVM User			
				JVM System			
				Machine Total			
<ul style="list-style-type: none"> ▼ Events by type 14.8 × 10⁶ <ul style="list-style-type: none"> ▼ Flight Recorder 26 <ul style="list-style-type: none"> Async-profiler Recording 3 Async-profiler Setting 23 ▼ Java Application 11.1 × 10⁶ <ul style="list-style-type: none"> Allocation in new TLAB 11 × 10⁶ Allocation outside TLAB 92,809 Java Monitor Blocked 0 Java Thread Park 18,056 ▼ Java Virtual Machine 3.66 × 10⁶ <ul style="list-style-type: none"> ▼ Profiling 3.66 × 10⁶ <ul style="list-style-type: none"> Method Profiling Sample 3.66 × 10⁶ ▼ Runtime 25 <ul style="list-style-type: none"> Native Library 25 Initial System Property 22 JVM Information 1 ▼ Operating System 122 <ul style="list-style-type: none"> ▼ Processor 121 <ul style="list-style-type: none"> CPU Information 1 CPU Load 120 OS Information 1 ▼ Profiler 79 <ul style="list-style-type: none"> Log Message 79 				3/8/22, 11:35:22.799 AM	68.8 %	24.8 %	94.7 %
				3/8/22, 11:35:23.799 AM	66.8 %	26.2 %	93.7 %
				3/8/22, 11:35:24.799 AM	64.3 %	25.6 %	91.5 %
				3/8/22, 11:35:25.799 AM	23 %	9.03 %	32.1 %
				3/8/22, 11:35:26.799 AM	68.3 %	26.4 %	96 %
				3/8/22, 11:35:27.799 AM	66.6 %	25.7 %	93.2 %
				3/8/22, 11:35:28.800 AM	68.2 %	26.2 %	95.6 %
				3/8/22, 11:35:29.800 AM	66.4 %	26.4 %	93.7 %
				3/8/22, 11:35:30.800 AM	68.5 %	26.2 %	95.8 %
				3/8/22, 11:35:31.800 AM	66.7 %	26.1 %	93.5 %
				3/8/22, 11:35:32.800 AM	68.8 %	26.1 %	96 %
				3/8/22, 11:35:33.800 AM	66.6 %	26.6 %	93.9 %
				3/8/22, 11:35:34.800 AM	68 %	26.8 %	95.9 %
				3/8/22, 11:35:35.800 AM	61 %	24.4 %	85.3 %
				3/8/22, 11:35:36.800 AM	0.0268 %	0.0893 %	0.938 %
				3/8/22, 11:35:37.801 AM	53.4 %	22.1 %	75.5 %
				3/8/22, 11:35:38.801 AM	68.8 %	26.1 %	96 %
				3/8/22, 11:35:39.801 AM	67.2 %	25.9 %	93.9 %
				3/8/22, 11:35:40.801 AM	68 %	26.7 %	95.7 %

案例：Java 8 ConcurrentHashMap computeIfAbsent 性能问题

<https://github.com/apache/shardingsphere/pull/13275>

```

17 ...apache/shardingsphere/infra/executor/sql/prepare/driver/DriverExecutionPrepareEngine.java
@@ -62,7 +62,22 @@ public DriverExecutionPrepareEngine(final String type, final int maxConnectionsS
62     super(maxConnectionsSizePerQuery, rules);
63     this.executorDriverManager = executorDriverManager;
64     this.option = option;
65     sqlExecutionUnitBuilder = TYPE_TO_BUILDER_MAP.computeIfAbsent(type, key -> TypedSPIRegistry.getRegisteredService(SQLExecutionUnitBuilder.class, key, new Properties()));
65 +     sqlExecutionUnitBuilder = getCachedSqlExecutionUnitBuilder(type);
66 + }
67 ++
68 + /**
69 +  * Refer to https://bugs.openjdk.java.net/browse/JDK-8161372.
70 +  *
71 +  * @param type type
72 +  * @return sql execution unit builder
73 +  */
74 + @SuppressWarnings("rawtypes")
75 + private SQLExecutionUnitBuilder getCachedSqlExecutionUnitBuilder(final String type) {
76 +     SQLExecutionUnitBuilder result;
77 +     if (null == (result = TYPE_TO_BUILDER_MAP.get(type))) {
78 +         result = TYPE_TO_BUILDER_MAP.computeIfAbsent(type, key -> TypedSPIRegistry.getRegisteredService(SQLExecutionUnitBuilder.class, key, new Properties()));
79 +     }
80 +     return result;
66     81     }

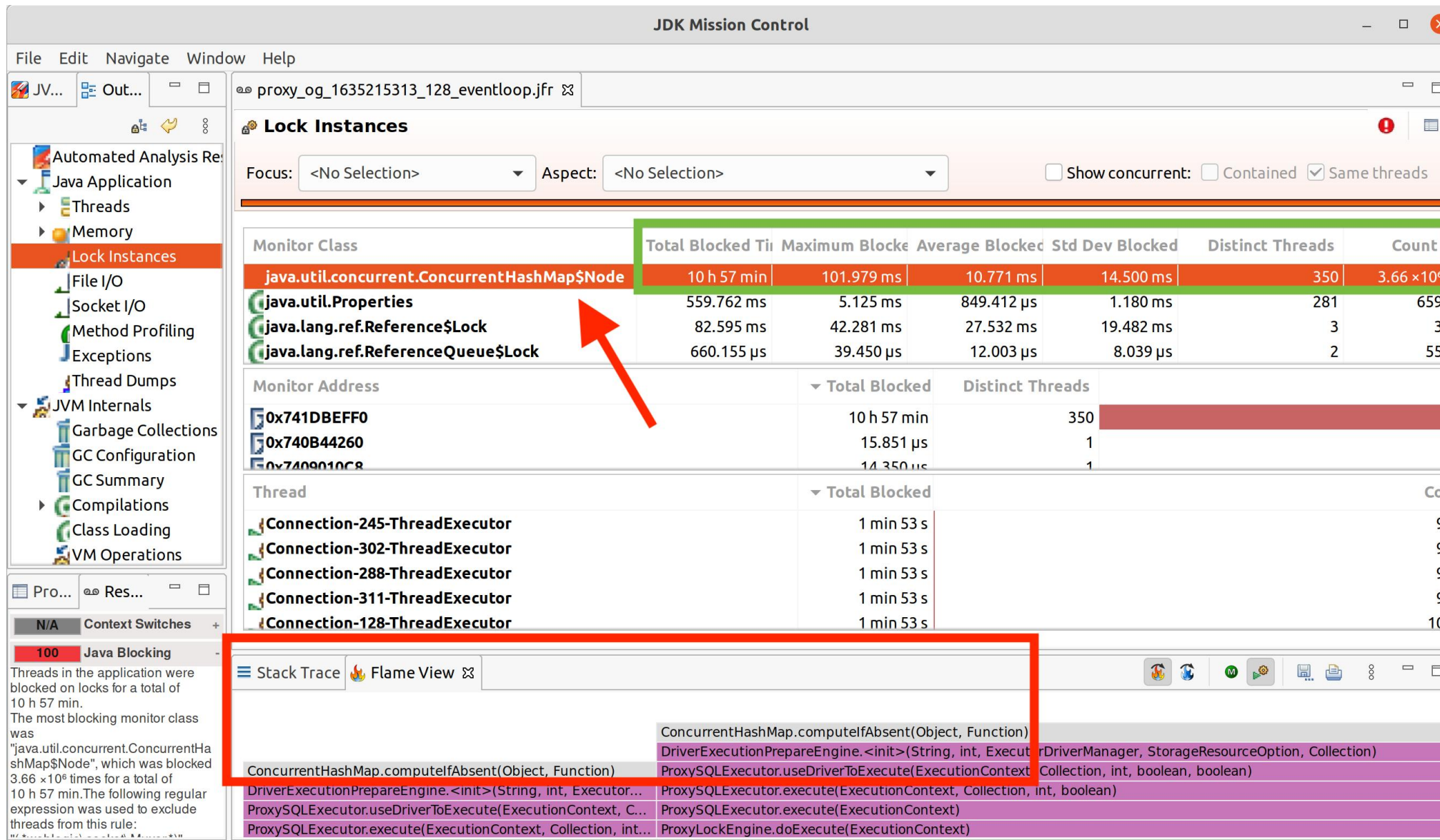
```

命令示例：使用 async-profiler 采集 JVM 进程中，阻塞超过 100us 的 lock，采样 60 秒并输出到文件 output.jfr

`./profiler.sh -d 60 -e cpu --lock 1ms -f output.jfr $JVM_PID`

案例：Java 8 ConcurrentHashMap computelfAbsent 性能问题

多线程使用相同 key 调用 computelfAbsent



The screenshot shows the JDK Mission Control interface. The 'Lock Instances' tab is active, displaying a table of monitor classes. The most significant entry is `java.util.concurrent.ConcurrentHashMap$Node`, which is highlighted in green and has a red arrow pointing to it. Below the table, the 'Thread' section shows several threads blocked on this lock, all with a total blocked time of 1 min 53 s.

Monitor Class	Total Blocked Time	Maximum Blocked	Average Blocked	Std Dev Blocked	Distinct Threads	Count
<code>java.util.concurrent.ConcurrentHashMap\$Node</code>	10 h 57 min	101.979 ms	10.771 ms	14.500 ms	350	3.66×10^6
<code>java.util.Properties</code>	559.762 ms	5.125 ms	849.412 μ s	1.180 ms	281	659
<code>java.lang.ref.Reference\$Lock</code>	82.595 ms	42.281 ms	27.532 ms	19.482 ms	3	3
<code>java.lang.ref.ReferenceQueue\$Lock</code>	660.155 μ s	39.450 μ s	12.003 μ s	8.039 μ s	2	55

The 'Thread' section shows the following threads blocked on the lock:

Thread	Total Blocked	Count
<code>Connection-245-ThreadExecutor</code>	1 min 53 s	9
<code>Connection-302-ThreadExecutor</code>	1 min 53 s	9
<code>Connection-288-ThreadExecutor</code>	1 min 53 s	9
<code>Connection-311-ThreadExecutor</code>	1 min 53 s	9
<code>Connection-128-ThreadExecutor</code>	1 min 53 s	10

The 'Stack Trace' section at the bottom shows the call stack for the blocked threads, starting with `ConcurrentHashMap.computelfAbsent(Object, Function)`.



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代码基准测试反面教材

```

1 ▶ public class WrongBenchmark {
    2 usages
2     private static final int TIMES = 10000;
3
4 ▶ public static void main(String[] args) {
5     benchThreadLocalRandomUUID();
6     benchDefaultRandomUUID();
7 }
1 usage
8 private static void benchDefaultRandomUUID() {
9     Random random = new Random();
10    long from = System.nanoTime();
11    for (int i = 0; i < TIMES; i++) new UUID(random.nextLong(), random.nextLong());
12    long duration = System.nanoTime() - from;
13    System.out.printf("Random UUID() took %4f%n", duration / 1000.0 / 1000);
14 }
1 usage
15 private static void benchThreadLocalRandomUUID() {
16    Random random = ThreadLocalRandom.current();
17    long from = System.nanoTime();
18    for (int i = 0; i < TIMES; i++) new UUID(random.nextLong(), random.nextLong());
19    long duration = System.nanoTime() - from;
20    System.out.printf("ThreadLocalRandom UUID() took %4f%n", duration / 1000.0 / 1000);
21 }
22 }

```

输出结果:

```

/usr/local/java/jdk-17.0.1/bin/java ...
ThreadLocalRandom UUID() took 1.738908
Random UUID() took 1.173566

```

调整 bench 方法顺序后输出结果:

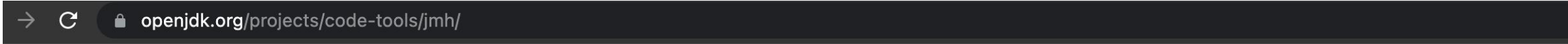
```

/usr/local/java/jdk-17.0.1/bin/java ...
Random UUID() took 1.813381
ThreadLocalRandom UUID() took 1.151652

```

Java Microbenchmark Harness (JMH)

<https://github.com/openjdk/jmh>



OpenJDK

- Installing
- Contributing
- Sponsoring
- Developers' Guide
- Vulnerabilities
- JDK GA/EA Builds
- Mailing lists
- Wiki · IRC
- Bylaws · Census
- Legal

JEP Process

- Source code
- Mercurial
- GitHub

Code Tools: jmh

See the JMH Source Repository for additional details.

JMH is a Java harness for building, running, and analysing nano/micro/milli/macro benchmarks written in Java and other languages targetting the JVM.

Links

- Source Repository
- Mailing List (archive)
- Bugs

案例：使用 JMH 测试 Java 8 ConcurrentHashMap computeIfAbsent

```
@State(Scope.Benchmark)
public class ConcurrentHashMapBenchmark {

    private static final String KEY = "key";

    private static final Object VALUE = new Object();

    private final Map<String, Object> map =
        new ConcurrentHashMap<>();

    @Setup(Level.Iteration)
    public void setup() {
        map.clear();
    }
}
```

```
@Benchmark
public Object benchGetBeforeComputeIfAbsent() {
    Object result = map.get(KEY);
    return null == result ? map.computeIfAbsent(KEY, __ -> VALUE) : result;
}

@Benchmark
public Object benchComputeIfAbsent() {
    return map.computeIfAbsent(KEY, __ -> VALUE);
}

public static void main(String[] args) {
    new Runner(new OptionsBuilder()
        .addProfiler(AsyncProfiler.class,
            "event=cpu;lock=100us;dir=/tmp/jmh-jfr;output=jfr")
        .threads(32)
        .forks(3)
        .warmupIterations(3).warmupTime(TimeValue.seconds(5))
        .measurementIterations(3).measurementTime(TimeValue.seconds(5))
        .build()).run();
}
```

案例：使用 JMH 测试 Java 8 ConcurrentHashMap computeIfAbsent

JMH 测试结果：

	Mode	Cnt	Score	Error	Units
benchComputeIfAbsent	thrpt	9	7737446.819 ± 2522383.120		ops/s
benchGetBeforeComputeIfAbsent	thrpt	9	783148861.986 ± 56766616.378		ops/s

GetBeforeComputeIfAbsent

- ▼ Events by type 7,904
 - > Flight Recorder 22
 - ▼ Java Application 0
 - Allocation in new TLAB 0
 - Allocation outside TLAB 0
 - Java Monitor Blocked 0**
 - Java Thread Park 0
 - > Java Virtual Machine 7,865
 - > Operating System 17
 - > Profiler 0

ComputeIfAbsent

	Start Time	Duration	End Time	Event Thread	Monitor Class
▼ Events by type 1.17 ×10 ⁶	7/6/22, 3:08:32.052 PM	294.762 μs	7/6/22, 3:08:32.052 PM	icu.wwj.jmh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No
> Flight Recorder 22	7/6/22, 3:08:32.052 PM	560.148 μs	7/6/22, 3:08:32.053 PM	icu.wwj.jmh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No
▼ Java Application 1.16 ×10 ⁶	7/6/22, 3:08:32.053 PM	541.058 μs	7/6/22, 3:08:32.053 PM	icu.wwj.jmh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No
Allocation in new TLAB 0	7/6/22, 3:08:32.053 PM	552.800 μs	7/6/22, 3:08:32.054 PM	icu.wwj.jmh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No
Allocation outside TLAB 0	7/6/22, 3:08:32.053 PM	552.800 μs	7/6/22, 3:08:32.054 PM	icu.wwj.jmh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No
Java Monitor Blocked 1.16 ×10⁶	7/6/22, 3:08:32.054 PM	530.897 μs	7/6/22, 3:08:32.055 PM	icu.wwj.jmh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No
Java Thread Park 0	7/6/22, 3:08:32.055 PM	507.443 μs	7/6/22, 3:08:32.055 PM	icu.wwj.jmh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No
> Java Virtual Machine 2,770	7/6/22, 3:08:32.055 PM	102.449 μs	7/6/22, 3:08:32.055 PM	icu.wwj.jmh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No
> Operating System 17	7/6/22, 3:08:32.055 PM	492.129 μs	7/6/22, 3:08:32.056 PM	icu.wwj.jmh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No
> Profiler 0	7/6/22, 3:08:32.056 PM	101.090 μs	7/6/22, 3:08:32.056 PM	icu.wwi.imh.dangling.ConcurrentHashM	java.util.concurrent.ConcurrentHashMap\$No

JMH 使用不当也会测不准代码性能

```
private double x = Math.PI;
```

```
private double compute(double d) {  
    for (int c = 0; c < 10; c++) d = d * d / Math.PI;  
    return d;  
}
```

```
@Benchmark
```

```
public void baseline() {  
    // do nothing, this is a baseline  
}
```

```
@Benchmark
```

```
public void measureWrong() {  
    // This is wrong: result is not used and the entire computation is optimized away.  
    compute(x);  
}
```

```
@Benchmark
```

```
public double measureRight() {  
    // This is correct: the result is being used.  
    return compute(x);  
}
```

代码来源于 JMHSample_08_DeadCode.java
更多示例请参考 JMH 源码 samples

测试结果:

Benchmark	Mode	Cnt	Score	Error	Units
JMHSample_08_DeadCode.baseline	avgt	5	0.437 ±	0.001	ns/op
JMHSample_08_DeadCode.measureRight	avgt	5	9.902 ±	0.019	ns/op
JMHSample_08_DeadCode.measureWrong	avgt	5	0.438 ±	0.003	ns/op

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Apache ShardingSphere GitHub: <https://github.com/apache/shardingsphere>

Apache ShardingSphere Slack Channel: <https://apacheshardingsphere.slack.com>

谢谢观看